BIONA-C Inflight Technology Demonstration

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The Biological Ion Analysis in the Cell Culture Module (BIONA-C) flew onboard the space transport system (STS-93) (July 23–27, 1999) as a technology demonstration of the capability to monitor and control pH measurements during spaceflight. Working with the U. S. Army Medical Research and Material Command (USAMRMC) and in close collaboration with the Cell Culture Module (CCM) team from the Walter Reed Army Institute of Research (WRAIR), Ames Research Center (ARC) developed BIONA-C as an autonomous monitoring and control system for a spaceborne hollow-fiber bioreactor experiment. BIONA-C monitored the pH and temperature of circulating media and controlled the collection of samples and addition of nutrients for the cells growing in the ARC Rail, shown in the figure.

The BIONA-C Rail contains four independent fluid paths that circulate media to support cell growth. In each path, media flows through a separate bioreactor where fluids can transfer across a permeable membrane to the cell culture, but cells cannot enter the fluid path. In two of the fluid paths the sensors are located directly in the circulating media ("online"), taking continuous pH measurements. Calibration of the online sensors occurs on Earth before and after the experiment. In the other two paths a precision pump periodically transfers media samples from the circulating media path to the sensors. This "offline" configuration allows the sensors to be calibrated inflight between each sample reading.

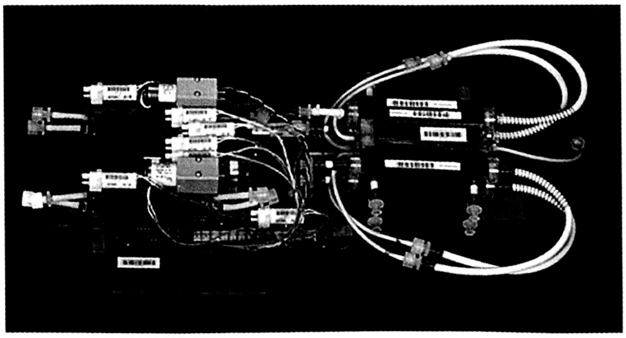

Fig. 1. BIONA-C Rail.

The sensor arrays are sealed and electron beam sterilized. Sterile practices are used during all experimental preparation, rail priming, and sensor calibration. When operating, the rail maintains the temperature of the bioreactor and oxygenator assembly at 37 degrees Celsius.

The capability to monitor and control bioprocess experiments gives BIONA-C enormous potential in the areas of space genomics, evolutionary biology, and astrobiology. The system has applications in cell growth and plant growth facilities in space. It can also be utilized in developing long-term, closed human habitats for future Mars exploration. The BIONA-C technology can be adapted to perform in measurement stations that search for life in extreme environments such as ocean floor hydrothermal vents.

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Solid-State Compressors for Mars ISRU

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One important way to extend the science and exploration capabilities of Mars surface missions is to use the readily available Mars atmosphere as a resource to provide critical supplies that would otherwise limit the mission or make it too expensive. Compressed and purified gases, oxygen, important chemicals, and even rover and rocket fuel can be manufactured largely from Martian atmospheric gases, saving the costs of their transport from Earth and ensuring that a mission doesn't end when it "runs out of gas." These techniques are examples of a popular mission strategy that is generally termed "in situ resource utilization," or ISRU.

The Mars atmosphere consists mostly of carbon dioxide, with relatively small amounts of nitrogen and other gases. At about 0.7 kiloPascals (0.1 pounds per square inch) total pressure, the mixed gases are too thin to be useful directly, so the atmospheric constituents must be separated from each other and